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GEOPHYSICS.—*A plea for geophysical and geochemical observatories.*[1]

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A volcanic system is known to the volcanologist as a place, not merely of kinds of processes, but of measurable events. In the course of events processes change. Nowhere is this so true as in a physico-chemical system dependent on pressure, temperature and saturation. The volcano edifice is a furnace changing these things in accordance with fixed laws of accumulation, of movement of the crust of the Earth, and of reaction with the watery and atmospheric envelopes that encase the crust. The relation of the volcano and its processes to these changing features of the globe through the seasons and the years, incessantly measured, is the most fundamental control for all the processes. Therefore the sending of geological expeditions concerned only with a process here, and a process there, will no more solve the volcano mystery than the sending of an expedition to Mauritius to observe an eclipse will resolve the orbits of the solar system. Let the astronomers say which is the more important, an expedition or an observatory. The expedition may furnish vitally important methods and data. Only the coöperation of fixed stations can collect these into a constructive science.

The comparison of geology with astronomy may be profitable to geology from another angle; namely, the application to the science of special invention and expensive apparatus. Astronomy and geology both deal with enormous bulks, gradual migrations, physical processes, chemical reactions, hidden masses revealable only by the aid of instruments of precision. From the time of Lyell geology has been increasingly dependent on the study of the living Earth to interpret the past. The life of the Earth's interior and of its outer shells, through the time of the present generations of men, is just beginning to be studied. With due allowance for the contributions of terrestrial gravity, geodesy, magnetism, and seismology, all of recent date,

[1] Received November 21, 1921.

produced rather by engineers than by geologists, the science of the Earth has yielded no Herschel, Huggins, or Hale, intent on improving the tools of the workman. Sorby's work on the petrographic microscope was good, but that was mineralogy, not measurement of the Earth. The hammer and compass still suffice for the geologist, and he borrows an aneroid or a transit from the engineer. No elaborate fluviometer costing hundreds of thousands of dollars stands on the banks of the Mississippi or the Ganges, comparable to the improved speculum of the star gazer. No mighty oceanometer has been invented for penetrating the deeps of the sea—unless it is the submarine, not yet available for the geologist. And no great Alpine observatory exists, with a staff of forty trained physicists and computers, and instruments which look inward at the core of the Himalaya and interpret every movement of uplift and erosion in terms of physical process and progress. Is this because the living Earth is less important to mankind than the number of units in a star-cluster or the diameter of a heavenly body? And yet nowhere on Earth, so far as known to the writer, is there a skilled geophysicist and inventor giving his whole life to an observatory devoted to measurement of change in a river system or a mountain range.

The perpetual measurement and record of these changes and their minutiae will not be done "somehow" or "anyway," and the results be stored in the libraries. It will not be done by travellers. It will not be done by teachers of school geography. It is not being done by engineers and governments and geological surveys. Little qualitative dabs are being done here and there but not quantitative records that will show cycles and crises, that may be platted as curves of change, that will create formulas useful in the discovery of the indices or coefficients of process for different places and climates.

The writer, from his experience of a decade of recording on an active volcano, is convinced that all that he learned in seven volcano expeditions to distant lands was as nothing compared with a few years in a fixed experiment station. He never had the slightest suspicion, from the travellers' accounts, of the number of changes which occur in a short time. Processes of which he never dreamed are dominant. Physical statements by reputable persons are proved wholly erroneous. Dimensions, even when estimated by engineers, are exaggerated. Interest never flags. Measurement of change becomes increasingly precise and the charts become increasingly illuminating. New problems open out endlessly and new experiments are suggested.

The old experiments get new meanings and need repetition with more precise method. Every day of observation opens up a new query.

The psychology of casual scientific visitors at Kilauea throws light on the statements which were made and recorded by similar travellers of a half-century ago, citing white heat, lava liquid as water, absence of flames, clouds of steam, floating islands, melting by lava, excessive heights and depths, and loudness of noises. The misstatements are due to failure to observe gases and their effects, and to preconceived notions, inexperience, hasty generalization, and the tendency to exaggeration which is never so dominant as on an active volcano. The will to explain is so much more active than the will to doubt and ascertain, that a bag-full of erroneous notes is carried off in triumph. As a matter of fact, doubting and waiting is necessary in presence of the unsolved and difficult problems of volcanism, the most enigmatical field in geology.

I recently asked the Research Information Service of the National Research Council about funds for fixed experiment stations dealing with eruption, erosion, sedimentation, and deformation as objects of measurement. Numerous inquiries by that Service failed to discover any specific provision for the kinds of research designated. Volcanology and seismology are meagerly supplied with fixed stations recording secular changes. Uplift and tilt in mountains and shorelines, erosion, and sedimentation, are not subjects of even experimental measurement having in view pure geology.

The sedimentation symposium directed by T. W. Vaughan is an admirable compilation revealing recognition of the need for a new method, but nowhere suggesting the observatory method. The phrasing refers to "problems" and the "need for critical studies" and correlation and classification, always with a mapping or a series of specimens in mind. Almost none of the experts has in view permanent secular measurement of rate of change and of kinds of change.

This idea suggests to the geologist an impossibility. He instantly says, "It would take too long." I reply, "Not only are you wrong, but your clocks must be set to Greenwich time and must split seconds to measure some of the accelerations of your sedimentation process. These sediments are filling intramontane basins, burying cattle bones on the plains, and shallowing the Gulf of Mexico." "Who has done any such work?" he asks. I answer, "George Ellery Hale at Mount Wilson." "But surely," says my friend, "you can't expect to do

that in geology, *for the Earth is so much more complicated.*" Whereat I laugh. He has asserted that the Earth is more complicated than the universe. His difficulty is due to confusion of ages of strata with the physical conception of rate of change. The hour, minute, and second are just as important to geology as era, period, and epoch. The first half of the textbooks of geology is misnamed "dynamical," for it contains no measurements of dynamical facts. The measurements needed will be rough at first, but they will gradually grow precise. This has been the history of meteorology and seismology, and geonomy is the same kind of science.

Dr. Daly has said that science is drowning in facts. Geological science is utterly lacking in measured facts of change within human time. Astronomical science is wholly made up of precision measurements of change within human time. Has this discouraged the astronomer? Dr. Hale says the supreme problems are the constitution of matter, the evolution of celestial bodies and the structure of the universe. The supreme problem of the Earth is the application of atomic theory to the evolution of the globe as a celestial body. Eruption, erosion, sedimentation, and deformation are surface manifestations of terrestrial evolution, just as comets, orbital motion, novae, and sunspots manifest celestial evolution.

When an astrophysical problem is to be solved, a certain star or nebula is selected as a type. The same thing may be done for sedimentation. Geographically delimit a certain strategic area and measure the changes there in relation to gravitation, crustal motion, atmosphere, water, and topographic form. Select an area where processes are rapid, and work thence to areas where they are slow. Do the work with trained physical experimenters and engineers. Do it with a view to pure geology, for purposes of discovery, and without economic bias. And finally, do it with the expectation that the institution will live after the individual has withered. The floods of a decade will yield unexpected results, the rates of accumulation will show seasonal and other rhythms undreamed of before, and, best of all, the problems which will open out for experimental treatment will themselves be surprises. If properly financed and manned, such a station will be more quoted than the Challenger expedition, and will take rank with Mount Wilson.

TENDENCIES IN THE GROWTH OF GEOLOGY

It is of interest to review the growth of geology for seeing whither

it tends. Like other sciences it originated in the needs of commerce. Just as botany grew out of "physic gardens" adjunct to medicine, so geology sprouted from the necessity of knowing coal and iron. Explained at first as abortive efforts at creation, the fossil shells and leaf imprints of the coal measures later became the hobby of doctors and curates inspired by William Smith and Lyell. In America vast mappings bred a hardy band of geologists, supplemented by topographers and railway men, exploring a wilderness of plains, deserts, mining districts, and mountains. These workers were partly army engineers, and for Britain such men also explored India and the Himalaya, and the problems of mass and magnetism, river erosion, climatal change and volcanic heat gained increasing prominence, when physically trained minds brought experimental method to bear on what had hitherto been merely descriptive. Next came formal organization under Government for studying rivers, harbors, the weather, sea bottoms for laying cable, the tides, terrestrial gravity and magnetism as affecting the instruments of astronomy, and the necessities of construction against fire, hurricane, flood, and earthquake. Agriculture, navigation, inland transport and mining, urban life, post and telegraph service, public time-keeping—all of these utilities are what have demanded expenditure of the public money to train experts in Earth process, just as coal and iron first produced experts in Earth history.

Earth history is dependent on Earth process, just as life is dependent on food, air, blood and brain. The physician of the one as of the other must have clinical experience. No geologist can doctor a coal mine who has never seen coal in the making. This is a startling assertion, but is it not true? Can any physician, not a quack, doctor blood and brain, restore life to morbid tissues, or even localize a bone, if he has made no experiments in hospital and dissecting room?

The whole of geology is increasingly leaning upon present history, Earth energy, geophysics. But we have seen that the historical science and the physical have independently sprouted from utilitarian needs. They have never been blended to aid each other as pure sciences. The toilers of the copper and iron mines, economic geologists, pick up crumbs that fall from the laboratory tables of the students of terrestrial gravity and magnetism, and vice versa, but neither understands the other's problem. I think it is true that neither geologist nor geodesist is making the slightest effort to find a place in the world today where copper and iron ores are being natu-

rally segregated, and there to study their electrical and gravitative effects. And yet at the Hawaiian volcanoes copper and iron sulfates and iron oxides are visibly concentrating, the magnetic declination values are various in an absurdly aberrant fashion, and the gravity phenomena of the heavy basaltic mountains are known to be extraordinary. All of this may be the key to Mesabi iron and Keweenawan copper, in ancient volcanic lands, but never an expert from those mines has come to Hawaii to find out.

OBSERVATORIES VERSUS EXPEDITIONS

The economic motive is apt to come to the front. Direct service to mankind is the measure of success. If this test is applied in the case of geology *vs.* geophysics, the customary alignment which places geology first (as explaining coal, petroleum and iron) may be defective. The Mississippi river system means more to more people than the succession of strata in the Illinois coal fields. Yet we know the Illinois coal fields, and no man living knows the Mississippi river system. The bogs may be making coal. No man knows the bogs. So we could run through the category of shore-lines, sea-bottoms, mountain streams, glaciers, springs, deserts, sand dunes, deltas, tide flats, volcanoes, and snowy peaks and show that no one knows the processes now going on, now changing and moving these things, in the sense of having measured them in relation to the passage of time. Just as a volcano occasionally reaches a crisis, so it is with a peak, a glacier or a delta; except by hearsay, no one knows these critical points or their controls. The peak may be breaking down, the glacier reaching a pressure limit, and the delta a limit of weight or height. An engineer with a ten million dollar contract dependent on knowing such rate of change would spend ten years, if need be, to measure it.

One of the most striking developments of continuous measurement at the Hawaiian volcanoes is the revelation of rhythmic recurrences. There are tides in the lava with maxima near midnight, a systematic upheaval of the solid crater floor by two or three feet every night. There are weekly, monthly and semi-annual culminations. There are cycles of about 9 years' duration, and there are possible cycles of 65 and 130 years. There may be longer cycles measured in tens of centuries. Rhythmic control appears in the tremors, earthquakes, and tilts with periods ranging from a half-second to a half-year. Anyone who has ever seen a loose monkey-wrench creep along the footboard of a vibrating motor-car is led to wonder whether this tremulous creaking earth-crust is not shaking down its mountains and its sedi-

ments by a similar mechanism. The determination of these periodicities has depended on the founding of an observatory, and only a decade of work has already laid the foundations for much useful discovery. Many phenomena before deemed exceptional are found to be commonplaces (Pelee spine). Others neglected before are found to be fundamentally important (aa lava). Chemical processes which were taken for granted, like oxidation, begin to loom large. Elements difficult to detect because of unperceived combustion and rapid diffusion, like hydrogen and helium, may prove more important in explaining volcanism than any of the obvious things. Chaotic-looking results are achieved by surprisingly gradual processes, even in volcanism, and immense bulks are moved rapidly with astonishingly little disturbance.

A temporary expedition cannot be expected to discover such things. An expedition expert is not expert in knowledge of the habits of the place he is visiting. So-called intensive studies by expeditions cannot reckon with past, present, and future critical events. The time element in physical control entirely breaks down. Agassiz in Galapagos found green slopes; he was amazed that Darwin had reported barrenness. They were there at different seasons. Often the evidence of a local consul or physician is more valuable than the opinion of experts. The solution of the coral reef problem is a Fiji observatory; the solution of the continental glacier problem is a Greenland observatory; the solution of the ore-deposit problem is a series of volcano and hot-spring observatories; and the solution of the erosion problem is a Mississippi observatory. Piecemeal notes patched together from library reading never yet made a discovery in natural history and never will. Human observation is such that often it must dwell with an obvious fact which it never sees for many years, until suddenly there comes an awakening. This is a commonplace of scientific progress, as biography shows. The specimen and the descriptive note are makeshifts, intolerable in the experimental sciences such as physiology, astrophysics, or meteorology; how large a part does a mummy, a meteorite, or a hailstone play in those sciences? So it is with geonomy, the science of Earth law. Men dwell on the Earth and live by its forces. No statement can be too strong in enforcing the importance of Earth processes for man.

In America the names of Dutton, Dana, Gilbert, Russell, Becker, Powell, McGee, Shaler, and Clarence King recall personalities of men who saw erosion, gravity, desiccation, accumulation, uplift,

unweighting of the Earth-crust, lifting of loads, and all such motions as more important, for their generalizations concerning past history, than anything contained in the dead rocks. They also studied these processes in action within the limits of their broad reconnaissance of a mighty continent. That reconnaissance expected a measurement of these movements by the next generation. The literature of geology is overburdened with expressions such as "possibly," "probably," "it may be assumed," "perhaps," and "according to current conceptions," all of which tend to hold it back from becoming a quantitative science.

The expedition method of intensive study of field problems is never free from the reconnaissance element, because of the unexpected phenomena which demand the manufacture of special instruments. Again and again in the writer's experience he has found himself in strange lands without the proper tools. However carefully prepared the equipment, pyrometers, gas-collecting devices, thermometers, sounding apparatus, transits, alidades, cameras, cableways, dredges, signals or what not, the explorer with limited time at his disposal finds that "here is the supreme opportunity" for so and so, and he has neither the man nor the equipment to test it. Perhaps it is merely one little piece of some peculiar metal or glass that he needs, perhaps it is a whole man, learned in atmospheric electricity, or a gun for throwing a rope, or a glass-blowing equipment and someone who can do the work. No matter how large and complete a shop and laboratory on the ship, there is needed a casting, a lens, or an implement made of fused quartz, and the vessel cannot produce it. Every recent expedition reports such happenings, owing to the great complexity and variety of requirements of modern science. Here is where the fixed observatory, if properly equipped and strategically placed, with machine-shops available and time to get men and apparatus as needed, and a whole life-time of deliberate work before the staff, can do what the expedition is not fitted for. Coöperative experts may be called in as occasion demands. The great endowed research establishments of the world attest the advantage of fixed stations, and the time has come for applying the method to geonomical processes.

A RIVER OBSERVATORY

Imagine a Fluviometric Observatory for the permanent increase and diffusion of knowledge about everything pertaining to the geophysics of the Mississippi river from the Yellowstone to the Alleghanies and from New Orleans to Minnesota. Its staff of physicists,

chemists, engineers, and assistants would be charged with the task of experimenting upon and measuring everything that can be learned concerning the changes in progress in the Mississippi, its basin, its sources, its waters and its sediment. Ultimately this institution would learn the natural history (literally) of that great organism, and the meaning of its presence and its probable future. This would yield new knowledge of other rivers, the Nile, the Congo, the Amazon, and of the philosophy of river basins in the economy of the continents. On no account would the observatory start with any preconcepts of physical geography. Its work would be purely quantitative and wholly devoted to water chemistry and the physics of gravitation and hydraulics acting on a complex surface to drain that surface and lower it by erosion acting under isostatic compensation. Isostasy, tilt, rainfall, temperature, wind, earth pressures, analyses, springs, rock decomposition and creep, silting, laking, floods, erosion pattern, earthquakes, uplift at fixed bench marks, biological controls, and delta sedimentation would be among the chapters in the record book. Mappings and repeated levellings would be among the station's achievements. New constants, new units and a new terminology would develop. No existing doctrine of orogeny, erosion, or sedimentation would be taken on faith—all would be tested in the crucible of relentless measurement through seconds, days, years, decades, and centuries. I would like to see such an institution liberally endowed, and as rigorous as the Bureau of Standards. Is there not a wealthy Mark Twain somewhere who loves the great "Father of Waters" enough to catch the vision of this institution, and what it would do for the world of men and the world of science?

A MOUNTAIN OBSERVATORY

It is worthy of comment that very few naturalists possess names immediately associated in the public mind with the places they have illumined by dwelling there.. Heim for the Alps and John Muir for the Sierra are types by way of illustration. There are those who have made many trips to the Rocky Mountains and have brought home specimens. But have they listened to the Rocky Mountains breathing in winter and summer, have they measured the change in cliffs and creeks and sage-brush flats, do they know the tremblings and the tiltings measurable in rock chambers in the face of a towering peak, have they for decades long surveyed lines from peak to plain, checked with levels? Have they studied the swayings of a mountain lake, the rise and fall of the brooks in springtime, the boilings of the geyser

basins, and timed the avalanches in the uppermost cirques? One can imagine a philosophical old prospector resident there, who knows more of the living forces that build the Rocky Mountains than any visitor. Not only must he who would be Master of the Mountain dwell there, like Seraphita amid her fjords, but he must work there and make lifelong measurements of change, until his faith has truly made the mountain move.

Anyone who has spent summers with pack-train in a place like the Yellowstone comes to know the land to be leaping. All night in camp 9000 feet above sea-level one hears the rocks from the precipice tinkling, sliding, crashing. A glacier booms through a deep crevasse. The milky stream carries off powdered rock by tons. A geyser terrace is hot, expanded; a neighboring summit is snow-clad, contracted. A herd of elk bounds up the slope with a clatter of rocks disturbed; every stone has been impelled nearer to sea-level. We hear much talk of water erosion; this is a land where tumbling and sliding do just as much as water. The mountains are falling all the time and by millions of tons. Something underground is shoving them up. Occasionally there is the whirlwind crash of a whole mountain-side, like the disaster at the mining village of Frank, Alberta. How many scores of similar slides occur in lonely places where no one even hears the noise? And how often? How much is the ground tilting? The genius who finances and mans the first mountain observatory will found a new science. Similarly we may imagine shore-line, glacier, desert, and sea-bottom observatories, ever inventing new instruments and revealing an unknown world.

Physical chemistry has worked wonders by synthesis in the laboratory, exploring rigorously a wide range of saturations, temperatures and pressures. There is needed direct comparison of these results with the complex analyses and syntheses which nature is always achieving. The comparison with mineral specimens studied in the polarizing microscope has been useful, but it is not enough. The astrophysicist never contents himself with a meteorite. Invention of field methods in geophysics is not keeping pace with laboratory skill. In contrast to the ultimates of modern physical research, the processes of the middle ground such as the motion of Tyndall's glaciers and the submarine subsidence postulated by Darwin are worthy of permanent stations, large staffs of specialists, big instruments, and endless refinement of measurement. The workers should live and die in their chosen field, they should create their own social group,

with students to act as assistants and computers, and welcome visiting travellers as co-workers.

Geological experiment stations on the mountains of Antarctica, the volcanoes of Chile, the sands of Sahara, the tide flats of Fundy, the foothills of Himalaya, the forks of the Amazon, eternally measuring creep, tilt, temperature and flood, will become famous not only as harnessing the globe with a web of pure reasoning, but will be fertile ground for sowing the seeds of peace and international coöperation. Science has been well described by Soddy as man's most eclectic religion, and no nation can object to an invasion by scientific missionaries.

The basis of physical geology resides in hydrogen and the evolution of the elements just as in the case of astronomy. But astronomy is basing all its newer work on astrophysics and astrochemistry. It is frankly pure and does not worry about getting itself applied. Earth science needs a new stimulus in the same direction. The observatory method furnishes a worthy and adventurous outlet for the pent-up energies of inventive young men trained in geophysics and geochemistry.

PALEONTOLOGY.—*Two new aphids from Baltic amber.*[1] A. C. BAKER, Bureau of Entomology.

In several blocks of Baltic amber recently purchased by the writer, there are preserved two interesting species of aphids, and a study of these specimens throws considerable light on the family as a whole. In the writer's generic classification[2] the genus *Mindarus* Koch was used as the basis of the subfamily Mindarinae, a group supposedly dominant in earlier times and quite distinct from the Eriosomatinae in which it had formerly been placed. Only one living form is known, *Mindarus abietinus* Koch, a cosmopolitan aphid living on conifers.

The blocks obtained show two alate specimens of a *Mindarus* very similar indeed to *abietinus* and a young nymph which we believe represents one of the earlier instars of the same thing. The remarkable similarity between this amber form and our common species can be seen by glancing at the figures in which the parts have been drawn to approximately the same size.

That the genus *Mindarus* was formerly well represented seems to be fairly assured. *Aphis transparens* Germ. & Ber.,[3] also from amber,

[1] Received July 26, 1922.
[2] Bull. 826, U. S. Dept. Agr. 1920.
[3] Org. Reste 2[1]: *pl. 2.* 1856.

undoubtedly belongs here. In fact it may even be the same species as that herein described. Unfortunately the description is very inadequate and it is only from the drawing of the wings that the species can with certainty be placed in the genus. *Lachnus dryoides* described by the same authors at the same time seems so similar to our immature form that there may be good reason to conclude that it represents young nymphs of *transparens*. This is also born out by the reports of other workers. Out of fourteen alate specimens found by Menge[4] in amber he referred thirteen to *transparens*, and along with these he found abundant a form which he referred to *dryoides*. In the same way Mochulskii[5] lists *dryoides* as the most abundant species represented in his material. Scudder[6] has erected many new genera from Florissant, basing them on the angle of the wing veins, a procedure which would seem dangerous in view of the fact that living forms show variation in this regard. He believed that the American forms are mostly quite distinct from the European ones. "American fossil plant lice," he says, "appear as a rule to differ from the winged forms so far described from the European Tertiaries with the single exception of the species figured by Berendt from amber under the name *Aphis transparens*..... The species is indeed an Anconatus."

Through the kindness of Nathan Banks I have been able to examine the Scudder material in the Museum of Comparative Zoology at Harvard. *Anconatus dorsuosus* Buckton, type of the genus, is represented by Numbers 3228 and 11175. Number 4827, from which Scudder's figure was made, is not present. The specimens on the other two blocks are not adequate to determine definitely the placing of the species. Neither can this be done from the drawing but Scudder's description, which seems not to agree with his figure, indicates that the species is probably a *Mindarus*. The ground is much more secure in the consideration of *Schizoneuroides scudderi* Buckton. From the very typical figure given by Scudder one would believe this species to be a *Mindarus* and an examination of the specimen shows this to be the case. Scudder's figure of *Pterostigma recurvum* Buckton suggests that this species also is a *Mindarus*. The drawing, however, does not seem to agree with the specimen. While the cubitus and anal are about as indicated, the media seems to arise much nearer the

[4] Progr. Petrischule. 1856.
[5] Etudes Ent. 5: 29. 1856.
[6] Tert. Ins. 1890.

radial sector. The general character, however, seems to be that of *Mindarus*.

It would be impossible to place definitely with their allies many of the species described by Scudder. One thing, however, seems certain. None fall in the subfamily Eriosomatinae (Schizoneurinae) in which he placed them. While details of structure cannot be seen, this fact is evident from the general nature of the specimens.

With the exception of those forms falling in the Mindarinae, all of Scudder's specimens, with one exception, are different from forms in recent genera. This species is *Oryctaphis lesueurii*. I am unable to make this form agree with the description and figure unless what shows as the stigma and radial sector are something quite different. The stigma appears to be truncate and the radial sector short and heavy like certain recent forms in the Lachnina. If this is actually the case, it indicates a remarkable difference from the other Florissant forms, all of which possess an extended stigma and a long radial sector arising far back on it. *O. recondita*, the second species of this genus, is quite different. It is very large and is not improbably a *Mindarus*. Scudder's figure hardly gives an accurate representation of it. The radial sector arises near the base of the stigma. The media can be traced almost to its base, and a branch is indicated very near its tip, much nearer than indicated in Scudder's figure. Scudder believed that this vein was twice branched but I believe the branch visible in the specimen to be the only one and that the insect might with good reason be grouped with *Mindarus*.

Many of the fossil aphids in the Scudder collection are not well preserved and it is perhaps as well to let them rest in the genera he described for them. Certain general characters are, however, worthy of mention. The most striking is the extension of the stigma and the insertion of the long radial sector. In many specimens the antennae are very long, suggesting some of the slender antennae in the Callipterina. Cornicles appear not to be present, and there seems little doubt that if the aphids possessed these heavily chitinized structures in any prominence traces of them would be preserved with the less delicate ones. Prominent cornicles are present in some of the species in amber, but these species have quite a recent aspect. We are forced to conclude that the cornicles were not prominently developed when the Florissant deposits were laid down. In only one specimen can I find traces of what may have been cornicles. This is a form which Scudder described as *Aphidopsis* sp. (No. 1044). In his description

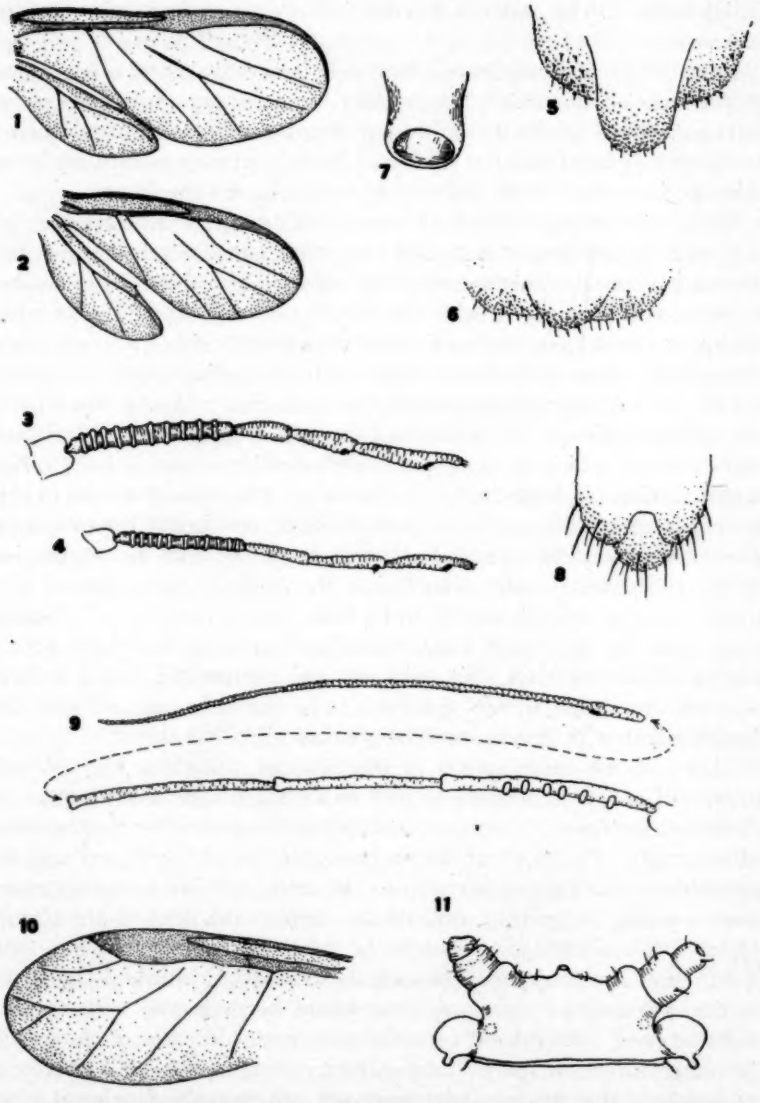

Fig. 1.—1, *Mindarus magnus*, wings; 2, *M. abietinus*, wings; 3, *M. magnus*, antenna; 4, *M. abietinus*, antenna; 5, *M. abietinus*, cauda and anal plate; 6, *M. magnus*, cauda and anal plate; 7, *Calaphis scudderi*, cornicle; 8, *C. scudderi*, cauda and anal plate; 9, *C. scudderi*, antenna; 10. *C. scudderi*, fore wing; 11, *C. scudderi*, head.

he mentioned these structures and described the insect as immature. It is, however, an alate specimen which has lost the wings, or possibly an intermediate, for the structure of the thorax is well preserved and the ocelli are visible. The cornicles, if they are cornicles, are broad at the base, short and somewhat tapering. The cauda seems to be knobbed and the anal plate bilobed. The entire insect suggests the genus *Euceraphis*.

A detailed reference to the other specimens in the collection could add little to the knowledge already available, but I believe that the remarks here given, together with the detailed description of the amber species, are sufficient to support the view that *Mindarus* is a genus formerly dominant but now represented by the solitary, cosmopolitan, conifer-feeding species *abietinus*.

The descriptions of the amber species given herein are the first in which any attempt has been made to give the more minute details of structure as is done in the description of living forms. This has been possible by use of the same high magnification adopted in studying recent aphids and the employment of powerful illumination. Even with the best light available, however, certain desirable characters remain obscured.

Mindarus magnus Baker, n. sp.

Alate viviparous female.—Head, thorax, and appendages appearing as dark brown. Abdomen yellowish, possibly greenish in life, with a large dark central dorsal marking irregular in outline. Wings transparent, the veins and stigma brown.

Length from vertex to tip of cauda 2 mm., width of head across the eyes 0.48 mm. Fore wing (Fig. 1) 2.88 mm. × 1.2 mm. at its greatest diameter. Hind wing 1.28 × 0.56 mm. Antenna (fig. 3) extending about to the wind insertions, segment III 0.24 mm. with 9 or 10 transverse sensoria, IV 0.08 mm., V 0.096 mm., VI (0.112 + 0.048 mm.), these segments distinctly imbricated and bearing the usual fringed sensoria. The measurements given for the antennal segments cannot be considered absolutely exact in view of the fact that they are not perfectly horizontal in the amber. In the second specimen, segment III of one antenna is 0.304 mm. long and segment IV appears to have 2 or 3 sensoria. Cauda and anal plate not distinctly visible but apparently as in Fig. 6, cauda possibly more extended in life. Cornicles obscured. Beak long, extending to about the middle of the abdomen.

Nymph.—What is possibly the 2nd instar of this species is herewith described.

Length from vertex to tip of cauda 0.896 mm. Length from vertex to tip of beak 1.36 mm. Antennal segments with the following measurements: I 0.032 mm., II 0.048 mm., III 0.032 mm., IV 0.032 mm., V 0.048 mm., IV (0.048 + 0.048 mm.). Form elongate, rather slender, segmentation distinct, color appearing brownish.

Mindarus magnus differs from *M. abietinus* in being much larger, in having a longer beak and in having somewhat stouter and relatively shorter antennae.

Described from three specimens in as many blocks, two alate specimens of which the type has the wings spread and one young nymph. The type and paratypes are temporarily retained in the author's collection.

Calaphis scudderi Baker, n. sp.

Alate viviparous female.—Head, thorax, and appendages appearing dark brown. Wings transparent with rather heavy veins. Abdomen brownish with dark markings above.

Length from vertex to tip of cauda 1.28 mm. to tip of wings 1.92 mm. Head (fig. 11) with the eyes very prominent and the antennal insertions distinctly transverse, median ocellus outstanding. Antenna (fig. 9) as follows: III 0.352 mm. with a row of sensoria which stand out distinctly, IV 0.256 mm., V 0.32 mm., VI (0.08 + 0.864 mm.). Segments distinctly imbricated, the distal one with the base not prominently marked off from the unguis, in this respect resembling *Monaphis antennata* (Koch). Cornicles (fig. 7) faintly visible but apparently short, somewhat tapering, with a slight constriction, and a large opening. Wings not unusual, the fore wing (fig. 10) showing a truncate stigma with a short distally set radial sector which is little curved

Cauda and anal plate (fig. 8) not clearly visible, but the anal plate somewhat bilobed and the cauda from the visible portion in all probability knobbed.

Described from one specimen with the wings folded over the back. Type temporarily retained in the author's collection.

I have placed this species in the genus *Calaphis* because it seems nearer this than to any described and I am loath to erect a new one for its reception. It represents a type of insect not present in the Florissant material but which is the usual type of living forms. This is especially evident in the wing, in the shape of the stigma and the radial sector. It indicates that while the more primitive forms represented by *Mindarus* are present in the Florissant beds and abundant in amber, the more recent type, dominant today, appears only in the amber.

GEOLOGY.—*The Lower Paleozoic section of southeastern Pennsylvania.*[1]

GEORGE W. STOSE and ANNA I. JONAS, Geological Survey.

The facts here presented are the results of comprehensive geologic studies in connection with detailed surveys in southeastern Pennsylvania by the writers and Eleanora Bliss Knopf for the Federal Geological Survey and the Pennsylvania State Geological Survey. A brief preliminary statement of the Paleozoic section that has been worked out and the formation names that have been applied are given in this paper.

Twelve miles east of Lancaster, Pa., the Cambrian quartzites of Welsh Mountain plunge southwestward beneath the limestones of the Lancaster Valley and rise again a few miles west of Lancaster in the Hellam-Chickies Hills.

[1] Published with the permission of the Director of the U. S. Geological Survey and the State Geologist of Pennsylvania. Received August 5, 1922.

The divisions recognized in the quartzites and limestones of this area and described below, are as follows:

GENERALIZED COLUMNAR TABLE

Age	Name	Thickness (ft.)	Character of Rocks
Ordovician	Conestoga limestone (probably older than, or in part equivalent to, Cocalico shale)	500±	Dark slaty limestone, coarse limestone and marble conglomerate, thin-bedded granular blue limestone, and thin graphitic slate. Contains brachiopods and crinoid plates and stems of probably Chazy age. Overlaps southeastward on all formations from the Ledger dolomite to the Harpers schist.
Ordovician	Cocalico shale	1000±	Dark gray shale containing graptolites of Normanskill type and thin crinoidal limestone at base; gray, green, and purple slates and green impure sandstone above.
Ordovician	Beekmantown limestone	2000±	Light blue limestone and some light gray magnesian limestone and dolomite, containing a little chert. Carries Beekmantown fossils.
Upper Cambrian	Conococheague limestone	900±	Massive blue limestone containing Cryptozoon reefs, thin-bedded wavy laminated limestones, sandstones and sandy conglomerates, and dolomite.
Middle Cambrian	Elbrook dolomite	500±	Cream-colored to white, fine-grained impure marble, mostly thinly laminated; weathers to shaly yellow tripoli and yellow earthy soil.
	Unconformity		
Lower Cambrian (Equivalent to Tomstown dolomite)	Ledger dolomite	1000±	Granular, gray to white dolomite, mostly thick-bedded, some beds of which are siliceous and weather to rust-stained granular cherty layers.
Lower Cambrian (Equivalent to Tomstown dolomite)	Kinzers formation	150	Siliceous banded dark blue limestone, impure dolomite weathering to dense buff tripoli, spotted white marble with wavy impure partings, and shale which contains an *Olenellus* fauna.
Lower Cambrian (Equivalent to Tomstown dolomite)	Vintage dolomite	500–650	Massive, glistening, coarse-grained, dark gray dolomite, weathering whitish with scattered crystalline blebs, and dark blue dolomite with argillaceous partings, weathering knotty or lenticular.

			Hellam-Chickies Hills	Welsh Mtn.	
Lower Cambrian	Arenaceous series	Antietam quartzite	200±	150±	Vitreous and granular impure quartzite, the upper part of which contains *Obolella* and trilobite fragments.
		Harpers phyllite	1000±	1500±	Greenish gray phyllite or biotite schist.
		Chickies quartzite	1000	550	Massive-bedded, *Scolithus*-bearing, light-colored vitreous quartzite, grainy quartzite with clear quartz grains, and some white clay beds in upper part.
		Hellam conglomerate member	(600)	(150)	Quartz conglomerate, grainy quartzite with rounded clear and blue quartz grains, and slate chlorite schist at base in Hellam Hills.
		Unconformity			
		Pre-Cambrian			Greenstone and aporhyolite in Hellam Hills; gneiss and granitic rocks in Welsh Mountain and Barren Hills.

Most of the Lower Cambrian arenaceous series is well exposed in the gorge of the Susquehanna River through the Hellam-Chickies Hills. The quartzite at Chickies Rock has been called Chickies quartzite since 1878, when the name was first used by Lesley and Frazer; they also used Hellam quartzite for the same rocks in Hellam Hills. Lesley and Frazer applied the name Chickies (Chickis) to the quartzite and associated "quartz slate" but not to the overlying phyllite, and later Walcott followed the same usage, applying the name Chickies to the quartzite. Conglomerate at the base of the arenaceous series was not mentioned by these early writers and apparently was not seen by them, as it is not exposed at Chickies Rock. It is brought to the surface three miles to the west in the midst of the Hellam Hills, where the anticline rises higher, and is there included in what was later called by Lesley Chickies quartzite. These basal conglomeratic beds, to which the name Hellam conglomerate member is here applied, correspond in general with the Weverton and Loudoun formations of South Mountain. The Hellam conglomerate member lies on epidotic amphibolite schist or greenstone and aporhyolite, which are altered volcanic rocks related to the pre-Cambrian metabasalt or Catoctin schist and aporhyolite of South Mountain. The basal beds of the conglomerate here are chlorite schist which contains glassy quartz grains and flat fragments of chloritic and rhyolitic schists,

apparently pebbles derived from the disintegration of the underlying greenstone and aporhyolite. The higher beds are dark slate and pebbly vitreous quartzite with interbedded coarse conglomerate which is made up of crowded round white quartz pebbles, 2 to 4 inches in diameter, in a sericitic siliceous matrix. The thickness of the Hellam conglomerate is estimated to be 600 feet.

The Chickies quartzite as exposed in Chickies Rock is a heavy-bedded light-colored vitreous quartzite and grainy quartzite with slate interbedded near the top, 400 feet thick. The quartzite carries *Scolithus* tubes throughout. It is similar to the Montalto quartzite member of the Harpers schist of South Mountain but as it lies at the base of the Harpers and not in its midst, it is probably not the exact equivalent of the Montalto. The Chickies quartzite, including the Hellam conglomerate member, is about 1000 feet thick.

The Harpers formation of the Hellam-Chickies Hills is a greenish gray phyllite with some biotite.[2] The bedding of the phyllite cannot be determined in most places, but the interbedded quartzite layers show several close folds. Although the thickness cannot be accurately determined it is estimated to be 1000 feet. The phyllite is overlain by light gray, somewhat calcareous, vitreous and granular impure quartzites, about 200 feet thick, some of the upper beds of which weather to a laminated, porous, highly ferruginous rock. These upper beds have the characteristics of certain fossiliferous beds of the Antietam sandstone of South Mountain, and their bedding surfaces show numerous rusty molds of *Obelella* and trilobite fragments. This quartzite is therefore equivalent to the Antietam sandstone (quartzite) of South Mountain.

The senior author has recognized in Welsh Mountain and vicinity the same divisions of the Lower Cambrian arenaceous series as are found in the Hellam-Chickies Hills. The Hellam conglomerate member in Welsh Mountain is made up of a grainy to finely conglomeratic quartzite and coarse quartzose conglomerate at the base, some of the pebbles of which are of clear blue quartz. The chloritic schist which occurs at the base of the section in the Hellam anticline is here absent because the pre-Cambrian rocks of the Welsh Mountain region from which the arenaceous Cambrian rocks were derived is

[2] The rock of the Harpers formation in the Hellam-Chickies and Welsh Mountain anticlines is referred to here as a phyllite to distinguish it from the more metamorphosed rock on the flanks of Mine Ridge, which is a schist. The senior author would prefer to use the term Harpers schist in both areas, which name he has used in previous publications on the South Mountain.

composed of an igneous complex of plutonic rocks and old sediments among which there are no greenstone schists. The pre-Cambrian, however contains conspicuous veins of glassy blue quartz, pebbles of which are inclosed in the basal Cambrian sediments. The conglomerate is well exposed near the sand mines northwest of Honeybrook, where it is only 150 feet thick.

In Welsh Mountain the lower part of the quartzite above the conglomerate is vitreous and the upper part is granular, both carrying *Scolithus* tubes. The granular quartzite is generally disintegrated at the surface and is quarried for sand. It passes upward into a fine-grained, white, siliceous, laminated clay, which is also mined. Four hundred feet of the formation has been measured in quarries and other good exposures. The Harpers phyllite, estimated to be about 1,500 feet thick, is composed of gray sandy phyllite. At the top the phyllite is interbedded with light gray, granular quartzite which weathers to a porous rusty rock containing molds of *Obolella* and trilobite fragments. About 150 feet of the upper quartzose beds are probably equivalent to the Antietam sandstone of South Mountain.

The arenaceous series of the Hellam-Chickies and the Welsh Mountain anticlines is overlain by the limestones of Lancaster Valley. The Vintage dolomite, the oldest of these limestones, is in part a gray, heavy-bedded dolomite, which weathers to a whitish chalky surface, and in part a knotty, dark blue dolomite with argillaceous partings. Some of the beds are sparkling, gray to blue mottled, with siliceous and calcareous blebs that stand in relief on the weathered surfaces. At the base is a whitish, schistose, thin-bedded impure dolomite containing muscovite flakes. This formation closely resembles the Tomstown dolomite on the northwest flanks of South Mountain. It, however, is known to represent only a part of the Tomstown dolomite and is therefore named Vintage dolomite from the small village 15 miles east of Lancaster, where most of it the section excellently exposed in a cut of the Pennsylvania Railroad.

The Kinzers formation which overlies the Vintage is best exposed in the Pennsylvania Railroad cut at Kinzers just east of Vintage. At the base there are a few thin beds of impure dolomite that weather to an earthy tripoli, containing at many places remains of *Salterella*, brachiopods, and trilobites. These beds are followed by a variable thickness of blue hackly shale as much as 50 feet thick in places. Northwest of Lancaster this shale carries abundant trilobites chiefly *Olenellus*, described by Walcott and extensively collected by Professor

Roddy of Millersville, Pa. Above the shale is a variable series of dark banded argillaceous dolomite that weathers to a tough, buff, ribbed, argillaceous rock, sparingly fossiliferous. Some beds are an intimate mixture of nodular white granular dolomite marble and dark impure dolomite that weathers to a knotty pseudo-conglomerate of white marble. South of Welsh Mountain the Kinzers formation is much thinner, in places not more than 25 feet thick, and the shale horizon there is not a prominent feature of the formation. Although no one section clearly exposes all the different beds of the formation, the section at the Kinzers cut is so nearly complete that it is here given in detail.

PARTIAL SECTION OF KINZERS FORMATION IN RAILROAD CUT, KINZERS, PA.

	Feet
Dark blue limestone with wavy impure partings	10
Thick-bedded light gray dolomite	12
Dark-blue limestone with wavy impure partings	6
White spotted marble with wavy buff dolomite partings	8
Blue limestone banded with slightly wavy siliceous layers	10
Highly siliceous banded dark limestone, weathering to skeleton of buff siliceous network	8
Impure thick-bedded dolomite, weathering to dense buff tripoli	3
White spotted marble with even buff dolomite banding	8
Wavy banded blue limestone, numerous argillaceous partings	10
Crumbly, fissile, dark shale, weathering spheroidal	50±
Impure dolomite, weathering to buff tripoli and containing few trilobite fragments and *Salterella*	7
Massive light blue dolomite (Vintage)	—
	132±

The Ledger dolomite, which overlies the Kinzers formation, is a granular gray to white dolomite, generally thick-bedded with few bedding planes. Because the bedding cannot be determined in many of its exposures and because outcrops are few owing to the readiness with which the dolomite weathers to a granular red clay soil, its thickness cannot be exactly determined. It is apparently about 1,000 feet thick. Although fossils have not been found in the Ledger dolomite, it together with the underlying Kinzers formation and Vintage dolomite are believed to be the equivalent of the Tomstown dolomite of Cumberland County. It is named from Ledger, 3 miles northeast of Kinzers.

The Elbrook dolomite, which overlies the Ledger dolomite north and northeast of Lancaster, is an impure, white to cream-colored, fine-grained dolomite marble which splits to fine plates and leaves on weathering and eventually breaks down to fragments of soft buff

tripoli and earthy yellow soil. It closely resembles the Elbrook limestone of Cumberland County and is correlated with it. The Waynesboro formation, a purplish sandy shale which lies between the Tomstown and Elbrook formations in Cumberland County but which dies out northeastward near the Susquehanna River, is evidently not present in this area. Because of poor exposures, the thickness of the Elbrook formation cannot be determined but it is estimated to be about 500 feet.

The Elbrook is succeeded by a series of limestones comprising thick pure light gray limestones which are apparently largely Cryptozoon reefs, thin-bedded finely laminated wavy limestones of related organic origin, sandy conglomerate beds which weather to pitted porous sandstone, and dark blue impure dolomite. This formation corresponds to the Conococheague limestone of Cumberland County. As many of its beds weather to earthy yellow soil similar to that of the Elbrook dolomite it cannot readily be distinguished from that formation on upland surfaces. It is estimated to be 900 feet thick.

Overlying the Conococheague are well-bedded pure blue limestones and magnesian limestones containing gasteropods. The fossils and the lithologic characters determine the formation to be Beekmantown. The Beekmantown limestone is estimated to be about 2,000 feet thick.

The Beekmantown limestone is overlain by a dark gray shale, gray, green, and purple slates, and soft greenish impure sandstone. The dark shales contain graptolites of Normanskill type and have at their base thin crinoidal limestones which are also fossiliferous. It is probably at least 1,000 feet thick. It is named Cocalico shale from the creek which exposes the shale where its relation to the underlying Beekmantown limestone is well shown.

South of the Hellam-Chickies Hills and Welsh Mountain there is a dark slaty and conglomeratic limestone formation that develops to great thickness south of Lancaster and eventually supplants all other limestones. Eleanora Bliss Knopf and Anna I. Jonas have called it in manuscript the Conestoga limestone. It has been traced and studied by them from Lancaster southward to Quarryville and into Chester Valley, but its relations are not there revealed. It was named Conestoga limestone because of excellent outcrops along Conestoga Creek, south of Lancaster. The Conestoga limestone is made up of thin-bedded dark slaty limestone, coarse conglomerate or breccia of limestone and marble pebbles and fragments, thin-bedded blue crystalline limestone, and thin, dark, graphitic slate. Its total

thickness is not known, but it is probably several hundred feet. The marble conglomerates that occur at or near the base were described by Walcott[3] as intraformational conglomerates in the Lower Cambrian sediments. At the Bellemont quarries, 12 miles southeast of Lancaster, one of the many excellent exposures, the conglomerates occur at about the horizon of the banded dark blue argillaceous limestone and knotty white-marble pseudo-conglomerate beds of the Kinzers formation, and at first were regarded by the writers as an expansion of this formation. Later work in other parts of the region has shown that the Conestoga limestone is an overlapping and much younger formation. In the northeastern outskirts of Lancaster, the coarse basal limestone conglomerate clearly fills depressions in the upper surface of the Ledger dolomite. North of Vintage, it overlaps on the Kinzers formation. At the Bellemont quarries it lies on the Vintage dolomite. Five miles south of Vintage it overlaps on the Harpers schist. The basal beds of the Conestoga are so variable that no consecutive section has been recognized for any distance, a fact that made it very difficult to distinguish the formation from the limestone on which it rests and to draw its boundary with certainty at many places. The characters of the basal beds of the Conestoga vary with the formation on which they overlap and from which they were largely derived.

West and north of Welsh Mountain the section is continuous from the Vintage dolomite up to the Beekmantown limestone with no indication of Conestoga type of sedimentation, and as the Conestoga is known to unconformably overlie the Ledger, it is believed to be younger than the Beekmantown. A few brachiopods and crinoid plates and stems recently found by the writers in the lower beds of the Conestoga limestone east of York, Pa., have been identified by Ulrich as forms found in the Frederick limestone of Frederick Valley which is probably of Chazy age. The Frederick limestone also somewhat resembles the Conestoga limestone in appearance and they are probably in part equivalent, but the greater thickness and extent of the lime-stones to which the name Conestoga is applied are believed to warrant a separate formation name. The Frederick limestone rests on Beekmantown limestone in Frederick Valley and the Cocalico shale rests on the Beekmantown northeast of Lancaster. The Conestoga limestone, which is an argillaceous limestone with many shaly beds, may therefore be in part the southeastward representative of part of the Cocalico shale.

[3] C. D. WALCOTT. U. S. Geol. Survey, Bull. 134: 17–19. 1896.

It is concluded, therefore, that in post-Beekmantown time, preceding Conestoga deposition, the southern part of the area was uplifted and the older formations were successively exposed by erosion from the Ledger dolomite near Lancaster to the Harpers schist at Mine Ridge, and that the Conestoga formation was then laid down across the eroded edges of these formations, the waste from the respective underlying formations being incorporated in its basal beds.

SCIENTIFIC NOTES AND NEWS

Dr. LEWIS M. HULL, who for several years has been engaged in studies of electron tubes in the radio laboratory of the Bureau of Standards, has resigned to accept a position as Director of Research of the Radio Frequency Laboratories, Inc., of Boonton, N. J.

E. A. SCHWARZ received the honorary degree of Doctor of Philosophy at the commencement exercises of the University of Maryland on June 10.

NORMAN SNYDER, a member of the scientific staff of the Radio Laboratory of the Bureau of Standards, left the Bureau June 1st for a leave of absence of several months. During this time Mr. Snyder will be with the Research Laboratory of the General Electric Co. at Schenectady, where he will work on electron tube problems.

PAUL C. STANDLEY, of the National Museum, returned to Washington in June from several months' botanical collecting in El Salvador and Guatemala.

Dr. KNUD STEPHENSEN of the Zoological Museum at Copenhagen, well known for his biological survey of the Brede Fjord in southwestern Greenland and for his studies on the Crustacea, accompanied by Messrs. TAANING and OLSEN, recently visited the National Museum.

Dr. RICHARD C. TOLMAN has resigned as director of the Fixed Nitrogen Research Laboratory to take a position in the California Institute of Technology. He is succeeded by Dr. F. G. COTTRELL.

E. D. WILLIAMSON, of the Geophysical Laboratory, left Washington in July to attend the meeting of the British Association, where he will present a paper on the high pressure work of the Geophysical Laboratory.